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DEVELOPMENT OF DECISION ANALYSIS SPECIFICALLY FOR ARCTIC OFFSHORE DRILLING ISLANDS

Ocean Engineering - 685 Report

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Advisor: **Dr. John M. Niedzwecki** of

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ABSTRACT

DEVELOPMENT OF DECISION ANALYSIS SPECIFICALLY FOR ARCTIC OFFSHORE DRILLING ISLANDS

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The theory and development of decision analysis for alternatives with risks is discussed. A procedure for decision analysis is then developed, by taking advantage of utility and probability theory, and applying this process to Arctic offshore drilling islands. A computer program was written as part of an example that compares three man made islands in the Arctic. Consequences of the three alternatives were based on factors such as ice loading, initial costs, transit time, along with six other attributes. The preferences of the design team for nine consequences, along with the likelihood of any single consequence occurring, was evaluated to obtain the optimum solution.

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CHAPTER I

INTRODUCTION

In the complex world in which we live, the program manager is constantly being asked to balance his judgments about various alternatives against the possible consequences arising from those alternatives. With the state of technology becoming increasingly more complex, this becomes a difficult thing to do, even for the experienced practitioner Decision Analysis provides a frame work in which to access alternative solutions to important real problems in a systematic and detailed manner. Formal techniques have been developed to aid the decision maker in making choices amongst various alternatives with a given set of consequences. The problem of uncertainty assessment has been dealt with in great detail, so assuming the evaluation of uncertainties is given, the problem becomes one of attempting to arrive at a decision while making sense out of our conflicting values, objectives, or goals. The emphasis of this paper deals with formalizing the preference side of the problem, rather than developing procedures to assess the uncertainties.

Decision Analysis has been successfully applied in operations research, systems analysis, management sciences, decision and control, and cybernetics. This report explores the application of decision analysis to engineering design. Decision Analysis is based upon a systematic approach to decision making in which the future consequences of decisions are not precisely known. The basic technique was developed by looking at the pattern in which a decision maker, or decision making group, chooses a course of action in an uncertain environment.

In the design of offshore structures decision analysis can present alternatives for structural designs that minimize the risk imposed by the uncertainties associated with the design installation and operations. Given the various options facing an engineer in offshore design, the question arises as to design parameters, such as design wave height, ice loading (in the Arctic), etc.. When properly used, the decision analysis method will give tradeoffs between costs and design wave height, production and depth of water for an oil platform, etc.. In short, this approach will help to clearly state which alternative is best suited for a given set of preferences of consequences.

Today, the necessity of making decisions in which the consequences are not fully understood, has become an integral part of our lives. Often we must act without knowing the entire set of consequences that will result from an action. This is uncomfortable for the program manager who must make far reaching decisions on complex issues in a rapidly changing technological environment, North (1968). Since the Project engineer and the Program manager may have differing views and preferences, the engineering science approach gives the program manager a tool in which the various preferences of consequences may be weighed against each other and analyzed. By comparing various alternative solutions, along with their consequences, a model can be developed in which the engineering objectives are varied with the managerial objectives to obtain the optimum solution. Albert Einstein once said "everything should be made as simple as possible but not simpler", Buede (1979), which is the basis of the engineering science approach of decision analysis. This iterative approach models the decision process by only modeling what is relevant to the decision and ignoring all others factors.

With most decisions that are required to be made, the interaction of a great many variables affects the outcomes of the decision. Interaction with the decision consequences is most adequately described in terms of probabilistic and stochastic measures. Decision theory is merely a formulation of common sense and mathematics is the language that best describes the decision making process. One can determine value, by means of utility theory; and information by means of probability theory.

After determining the possible alternatives and their outcomes, the assignment of a numerical value to these alternatives is achieved through the use of utility theory. Probability theory is used to consider the likelihood of a given outcome to occur, rather than looking at the evaluation of the outcomes that might occur.

CHAPTER II

DEVELOPMENT OF A DECISION ANALYSIS MODEL

The problem of optimizing the type of platform that is best suited for a particular site has become an extremely difficult decision. Over fifty-one different types of drilling and production platforms have been identified for the Arctic environment, with new concepts being developed every year, Boslov et al (1983). Together with the uncertainties due to unfamiliarity of the ocean environment, the scarcity of data on load and material behavior, and the high costs of data gathering, the decision making process lends itself to the decision analysis theory.

By using utility and probability theories, a method may be formulated for a decision analysis approach. There are four fundamental assumptions made in using utility theory: (1) that any two possible outcomes resulting from a decision may be compared, North (1968); (2) that a preference can be assigned to the lotteries involving consequences in the same manner as to the consequences themselves, von Neuman et al (1947); (3) there is no intrinsic award in a lottery between consequences, North (1968); and (4) is a continuity assumption.

The first assumption says that given a choice between two alternatives, the decision maker can choose which he prefers. In some cases, the decision maker can be ambivalent between the choices offered him. It is not necessarily the comparative costs, but rather what the decision maker prefers that is important.

The second assumption involves choices between different consequences. If given two alternatives then the alternative with the highest probability of receiving the preferred consequence would be chosen.

This leads to the third assumption, that is, "no fun in gambling". A compound alternative involving a choice between still other alternatives, may be reduced to a single alternative. The preferences are not affected by the way in which the uncertainty is resolved. If the alternatives are compared, whose sum totals of many smaller uncertain consequences, then the decision may be based on a comparison of the expected consequences from each alternative.

The final assumption implies there must exists some probability P such that it is indifferent over a single consequence or an alternative with various other consequences. North, in his paper "A Tutorial Introduction to Decision Theory," gives a complete discussion and examples of these four assumptions.

The utility of an alternative is the mathematical expectation of the utility of the consequences. As long as the utility function is linear, it is an easy matter to maximize the expected utility. However, if the utility function is curvilinear, then it is necessary to know the probability distributions from alternative courses of action in order to ascertain which alternative has a maximum expected utility.

The likelihood of a consequence occurring, or the confidence the decision maker has in his assumptions, is determined by the decision maker. It reflects his best judgment based on all the information available to him (inductive reasoning). Thus, as more information becomes available, the probability of occurrence assigned is subject to change. This leads to the aspect of probabilities of probabilities occurring. The most important aspect of the probability function is to aid in the confidence that a decision maker has in his assignment of the utility function.

One must consider the parties involved in the decision making process. For simplicity, consider two basic groups involved in the decision process for offshore structures. Engineers, who for example, are concerned with the risk of structural failure given a load condition, and management, who is concerned if this is an acceptable risk in view of economic or production loses. The final product, or decision, is a joint effort of all parties involved.

In evaluating various structural alternatives, it might be the engineer who assigns the utility function to a particular category or alternative. But it might be the manager who will assign the preference on how important a particular attribute is, in view of the other consequences.

The primary alternatives given the decision maker usually implies various levels of costs and risk. If one tries to design for all the uncertainties, then the cost of the structure will undoubtedly become prohibitive, however the risk will be negligible. Often, the solution with the highest risks has the lowest initial costs, while the solution designed for low risk, will have a much higher initial costs associated with it. The tradeoff between risk and cost is the primary feature of the decision making process. Figure (1) shows the classical form in which only the

economic loss due to failure is considered. The total cost is the summation of the initial costs and the expected cost of failure:

$$E(C_T) = C_I + E(C_f) \qquad (1)$$

where: $E(C_T)$ is the expected total costs

C_I is the initial costs

$$E(C_f) = E(C|F) \cdot P_f \qquad (2)$$

where: P_f is the failure probability during the design life

$E(C|F)$ is the expected costs in case of failure

This provides for analysis of only one structure at a time with a single consequence, economic loss due to failure. When faced with many different structures as alternatives, and each alternative having several consequences, a comparison between the benefits and draw backs of each structure is important to the decision maker. This is the basis for developing a computer simulation which compares multiple structures, with several consequences that do not have a common unit of measure.

The decision analysis procedure gives the decision maker a means in which to analyze various alternatives between structures. The problems' consequences, and their likelihood of occurrence, along with their preferences are combined to determine the expected utility for each of the design alternatives. The expected utility provides a basis for a comparison of the alternatives, and is an objective function which is to be optimized over all the alternatives.

The steps for decision analysis may be identified as, Bea et al (1984): (1) Structuring the problem; (2) determining consequences of alternatives (the risks); (3) Determining preferences for consequences; and (4) Evaluating alternatives.

Structuring the Problem

In order to properly structure the problem, it is important to focus attention on what is the actual problem. By defining the scope, the decision alternatives are identified. For a given set of circumstances, it is possible to generate alternative designs for each part of the problem. For example, if we were considering the design of an offshore structure, then we should be able to generate design alternatives for the subelements of the substructure and superstructure. The result of the design alternatives may provide an effective means to increase the efficiency of the problem under consideration. This could be in terms of initial costs by a better engineering design of the platform, or by production capabilities by the selection of the site/structure chosen by management. The key design parameters are considered, leading to alternate design options. The number of the alternatives generated can be reduced by eliminating any unrealistic combinations. This number can be further reduced by looking at the extreme cases, and where two alternatives are significantly similar, eliminating one of them.

The criteria for the evaluation of the alternatives should be carefully defined so as the include all the important aspects of the problem, such as costs minimization and reliability maximization. For decision analysis, this criteria need not be measured relative to a common unit of measure. For example, the measure for the effectiveness for the reliability of a platform design may be: (1) Total costs (initial and life cycle costs); (2) losses of life; (3) environmental impact. The environmental impact can be described in costs of barrels of oil spilled. However the loss of life is a hard one. Loss of life is obviously a very important measurement for any design. But how much is one life worth, and how many lives are considered

acceptable? This would be simple if one only considers the costs to replace a man, legal costs and the like, but what about bad publicity, not to mention the morale factor of the people working aboard the structure.

In order to properly structure the problem, the identification of the decision makers and groups affected by the decision becomes an important task. They may include industry-government bodies, along with citizens and environmental groups. Careful selection is required, for it is these people who will develop what preferences should be considered when evaluating possible consequences.

Consequences of Alternatives

By using existing data, new data, professional judgment of experts, or any combination thereof, the assessment of the various possible consequences from the selection of the various alternatives can be performed. This assessment describes the consequences that can happen if any of the alternatives are selected. An applicable consequence could be composed of: (1) An estimation of the likelihood of damage, and (2) consequences with various levels of damage. By doing an analysis of each alternative, the likelihood associated with, and the consequences for, each alternative can be defined and modeled. A kind of "cause and effect relationship", based on probability of occurrence and estimated consequence, can be formulated. The consequences are in terms of the criteria set up for the design alternatives.

Preferences for Consequences

Once the consequences have been identified, it must be determined if one set of consequences is preferred, indifferent to, or not preferred over another set of consequences. By using utility theory, one sets up preferences for situations, rather than to compare alternatives. Comparing

situations is much easier to do. Utility theory then determines the preference order based on complex situations for the alternative, that the decision maker should have in order to be consistent with his decisions that he made for simpler situations.

In order to gather the necessary information from the appropriate decision maker, one may use any number of standard interview techniques. Keeney et al (1976). Quite simply, the individual utility functions quantify how much one likes (dislikes) various levels of each attribute of the consequence, while a scaling function (k_i) is introduced that rates these attributes against each other, or the preference of one attribute over another. The scaling function (k_i) quantifies how much the decision maker is willing to give up on one attribute in order to gain on another attribute (attribute tradeoffs).

Evaluation of Alternatives

The alternatives developed, the probable consequences for each alternative addressed, and the multiattribute utility functions defined are integrated in a rational manner such that the expected utility for each utility value is defined. The expected utility is a single number that becomes the basis for the ranking of the overall desirability of the alternatives. The uncertainty associated with the consequences measured for each alternative attribute and the preferences for the attributes are incorporated in the calculation of the expected utility function.

To consider how changing the variations of the possible outcomes, and the preferences for the attributes, affects the order ranking of the alternatives, a sensitivity analysis should be conducted. First conduct the analysis by using the "best estimates" available. Then variations about this case should be examined. Thus, it is possible to define the points at which

the alternatives change their ranking order. This will be most useful in demonstrating the range of conditions over which the order ranking of the alternatives remains constant.

Figure (2) is a representation of the the decision analysis approach for a structure. For each alternative of design, the likelihood of possible consequences is estimated. Then the evaluation of the preferences for the consequences is performed to give the multi attributed utility function. Finally, the probable consequences and preferences for consequences are combined to establish the expected utility of each alternative, which are then used as a basis to select the optimal design.

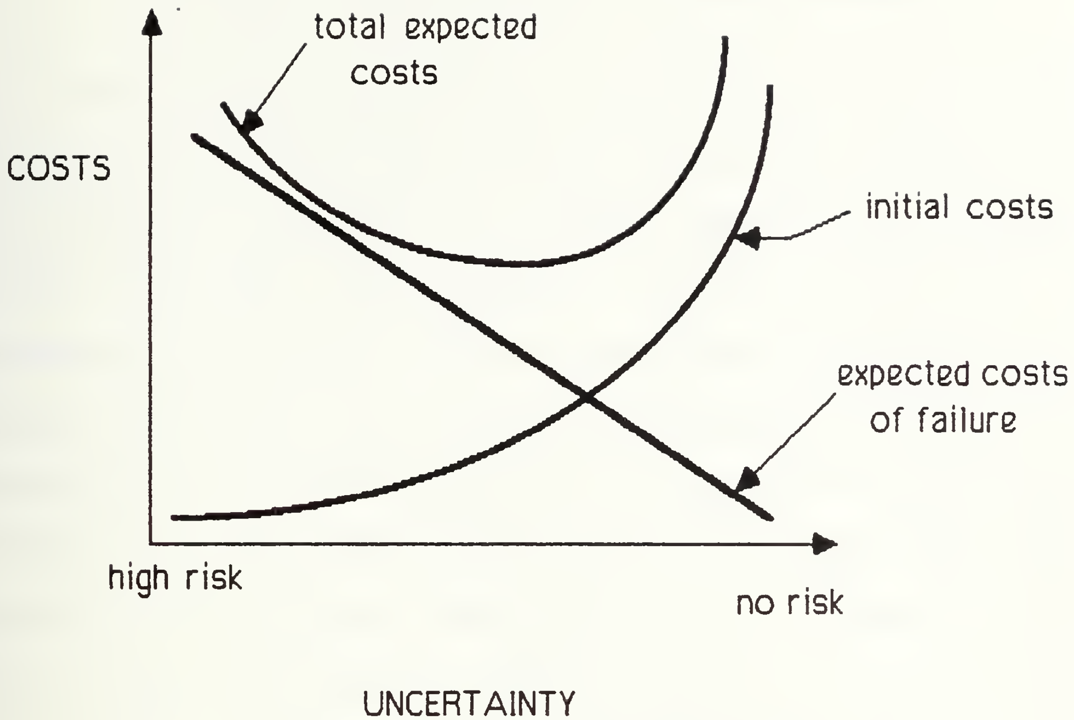

Fig. 1 Expected Cost Minimization

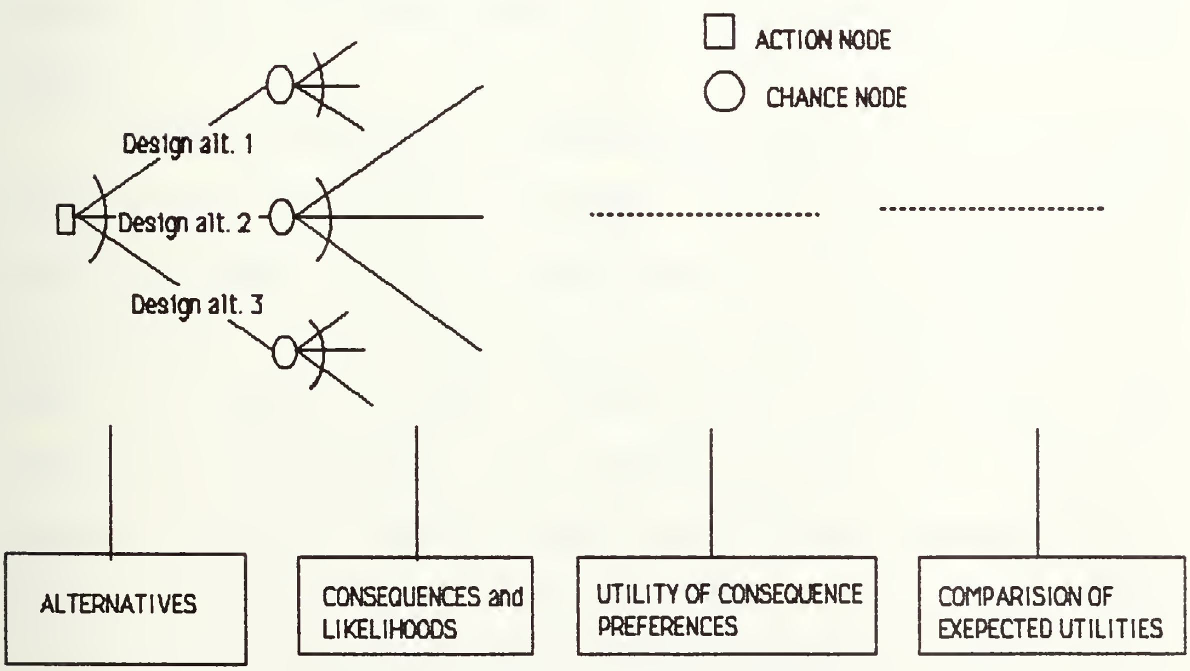

Fig. 2 Decision Analysis Approach

CHAPTER III

APPLICATION TO ARCTIC OFFSHORE ISLANDS

The following example explores the application of decision analysis to the selection of an offshore structure for a shallow water site. The Arctic environment provides one of the most challenging environments for offshore exploration. Many types of offshore structures have been proposed for the Arctic environment. They can be classified into four basic groups; (1) man made islands, (2) mobile drilling rigs, (3) fixed offshore structures, and (4) complaint structures. Each of the proposed structures is based upon proven technology but, there is no single design which is suited for all of the offshore lease sites. Thus it is necessary to compare several design alternatives in order to determine the optimum structure for a given site. Experience has shown that offshore man made islands provides the best type of platform for shallow water in Arctic oil drilling activity. They are relatively easy to construct and may be used year around.

Consider the situation in which there are several proposed sites, ranging from 10 feet to 60 feet in depth, with the anticipated production varying with depth. The total decision tree for this problem might look like figure (3). How the costs of the Earth Filled Structures varies with depth is of particular concern. Three types of earth filled man made islands will be considered. The sacrificial island is the easiest to construct, however it requires beach protection and rebuilding. (Fig. 4). Caisson retained earth filled islands have better ice resisting capabilities, but the draft of the caissons limits the site to where the caissons may be floated. (Fig. 5).

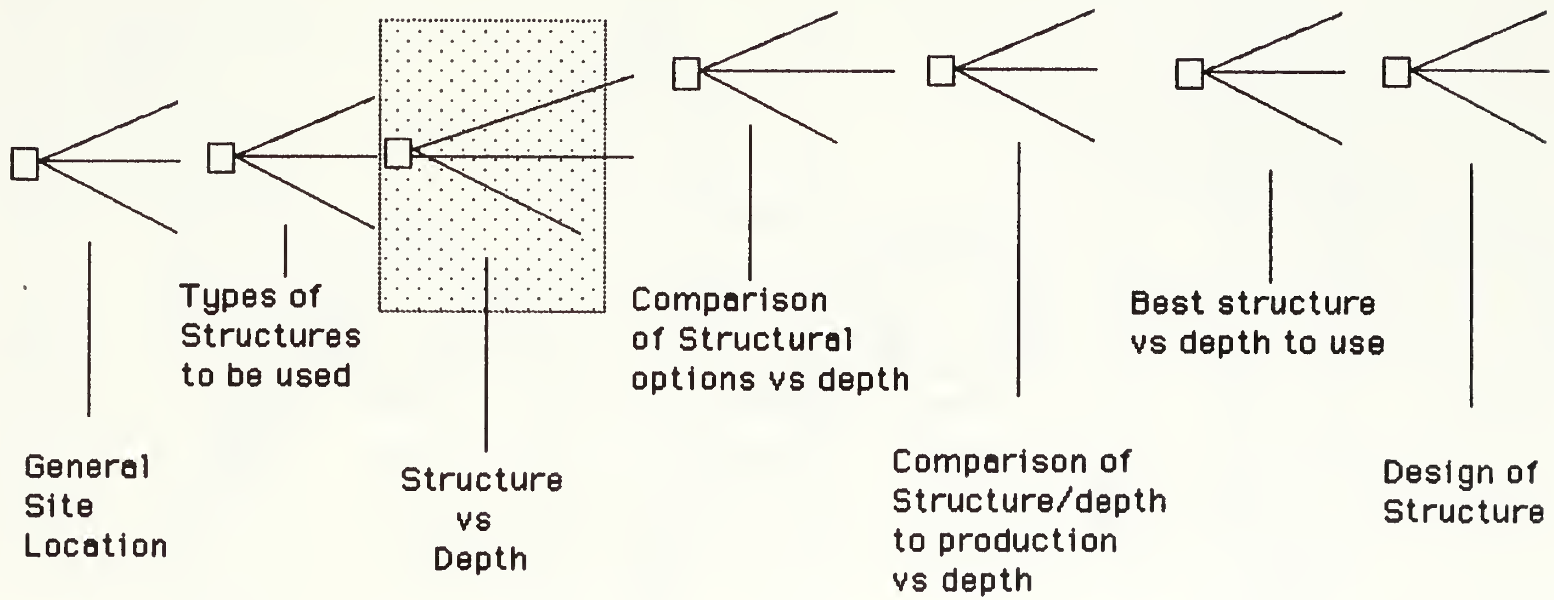

Fig. 3 Decision Schematic

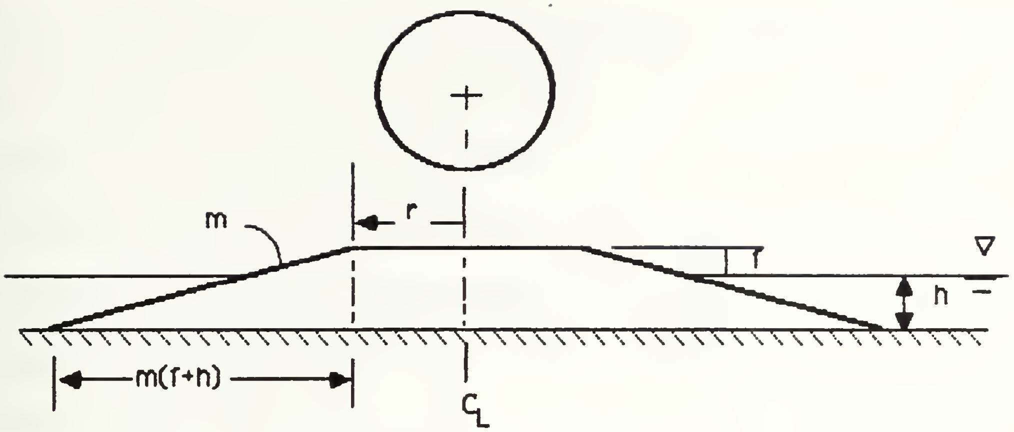

Fig. 4 Sacrificial Arctic Island

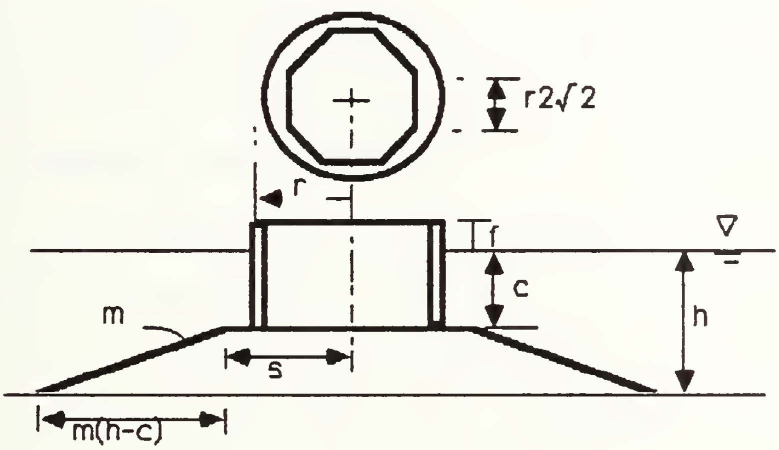

Fig. 5 Caisson Retained Arctic Island

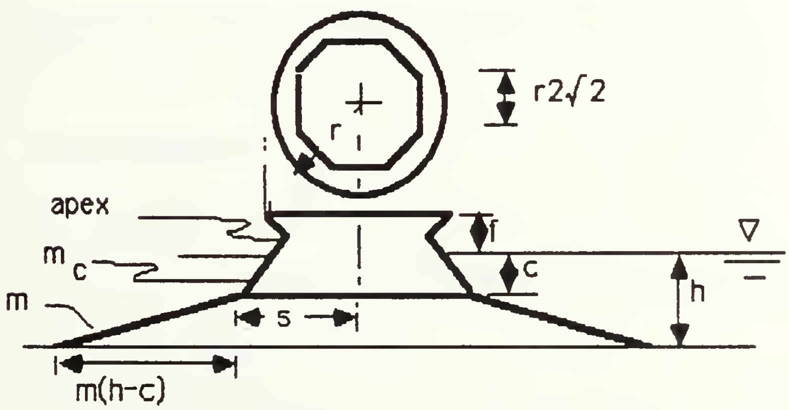

Fig. 6 Slope Sided Caisson Retained Arctic Island

By putting a slope on the caisson, the slope sided caisson retained island, the ice resisting characteristics are greatly improved. However, the time and effort of construction are increased. (Fig. 6).

These structures will become the three design alternatives. What must be determined is, for a given depth, which one of the alternatives is the most economical to construct, while optimizing the consequences to the fullest advantage.

Categories

There are many other factors that can be taken into account but, the criteria has been limited for this study. The working platform is required to have an equivalent of a 300 foot diameter. The freeboard is taken as $^1/_4$ of the water depth. The structural design is assumed to be dependent on the water depth. The required fill is supplied by dredge material on-site. The initial costs are dependent only on the amount of dredge material and concrete used by the structure for a depth. The cost of the dredging is assumed to be 12.0 dollars per cubic yard, and the cost of the cement and labor for the caissons is taken as 55.0 dollars per cubic yard. In addition the following assumptions have been made for the three types of man made islands used in this example:

(A) Sacrificial Man Made Islands:

The Sacrificial Island is assumed to have a constant slope of 1:20.

(B) Caisson Retained Man Made Islands:

1.) For a water depth of 0 feet to 15 feet, the caisson wall thickness remains constant at 15 ft.

2.) From 15 feet to 30 feet, the caisson thickness is related to the water depth by 2c/3, where c is the depth of the caisson. Further, the caisson is able to sit on the ocean bottom up to depths of 30 feet.

3.) From 30 feet to 60 feet, the Caisson Retained Islands are sitting on a berm, the slope of the berm is assumed as 1:20. 60 feet is considered the limit for a Man Made Island without stacking caissons.

4.) The berm diameter at a water depth of 30 feet is taken as 400 feet.

(C) Slope Sided Caisson Retained Man Made Islands:

The assumptions are the same as for the Caisson Retained Island, with the following exceptions:

1.) The berm diameter at a water depth of 30 feet is taken as 500 feet.

2.) Slope of the caisson is taken as 1:1

3.) The apex of the slope is at 9 feet from the top of the caisson.

Of course there are many categories that might be of importance, but for now just consider the ones listed below. In the development of each category, several types of interviewing techniques or design procedures may be utilized. The concept is to rate the preference of the values within each category.

1.) **Initial Costs:** The costs for construction of the Island as a function of water depth. Maximum function occurs at the lowest price. The initial costs are decided by design. In this case, only the material costs such as the land fill and concrete required are considered. The first step is to determine the initial costs of each alternative with

respect to depth. Appendix A gives the equations developed for the amount of fill and concrete required.

After finding the initial costs, the next step is to find the utility of this category. In order to do this, a preference must be made for the amount of money willing to spend. By establishing the firms economic policies, a utility curve for costs may be constructed. The choice of a zero point and scale factor is arbitrary, so for this curve let us choose a scale of 0 to $500,000,000. Let $500,000,000 have an utility value of 0 (least preferred), and $0 as having an utility value of 1.0 (most preferred). Assume that $25,000,000 is the point of indifference as to whether or not to leave the decision up to chance by the flipping of a coin. Therefore, the utility of 0.50 is associated with $25,000,000. Of course such an important decision would never be left to the flip of coin, but there might be indifference as whether or not to use a new type of structure, or use the same structure the firm has been using for the last 40 years. More likely, some sort of statistics and probability density curves would be employed. By listing and rating such tradeoffs, a utility curve for the initial costs might be constructed as in figure (7).

Now, with the initial costs of the various alternatives calculated, by using figure (7) the utility function of each alternative's initial costs may be determined.

2.) **Adaptability:** The ability of the island to adjust for various water depths during the design phase. Maximum for this function is when the structure can be built in all depths of water under consideration. This category is evaluated on the views of experts in the field. Assume on a scale from one to ten, it was found that the utility curve is a straight line. A utility value of 0 (least preferred) is for low adaptability, while

being highly adaptable (a 10 on the scale) is assigned a utility value of 1.0. (Fig. 8). From the firm's experience, and the expert's advice, the Sacrificial Island was assigned an adaptability rating of 0, while the Caisson Retained Island and the Slope Sided Caisson Retained Island are assigned a value of 4.0, since the caissons may be made for a maximum height and used in various water depths. The straight line curve utilized in this example is constructed for simplicity. In actuality, tradeoffs similar to those done for initial costs would have to be performed.

3.) **Transit Time:** Mobilization time for the first ship (or plane) to leave port to the time when the last ship arrives on the construction site. This becomes an important factor since the Arctic environment has specific time windows for transit. The shorter the transit time, the higher value for this category. This category, like the adaptability category, is based on good judgment and experience. For this example, take it as a straight line, with a short transit time having a utility value of 1.0 (most preferred), and a long transit time having a utility value of 0 (least preferred). (Fig. 9). Since the Sacrificial Island requires primarily dredges only, the transit time is taken as being 30 days. The Caisson and Slope Sided Caisson Retained Islands, due to the extra transit time required of the caissons, the time is taken as 35 days. If over 50 days are taken, then the transit time is considered unacceptable since this would not leave enough time for construction during the short ice-free season. Therefore, 50 days is assigned utility value of 0.

4.) **Depreciation Costs:** The amount the structure depreciates after 5 years. Maximized when the costs are zero. Figures are based on sound business judgment and calculations. Assume the Sacrificial Island is determined to have a depreciation of $5,800,000 at the end of 5 years,

while the Caisson Retained Island has a depreciation costs of $4,300,000, and the Slope Sided Caisson Retained Island has a $3,800,000 depreciation at 5 years. Further assume that under no circumstances would the 5 year depreciation costs be greater than $10,000,000. Therefore, the utility value of 0 is assigned to $10,000,000, (least preferred), and $0 assigned to a utility value of 1.0 (most preferred). Note that these may not be realistic costs, but it does demonstrate this utility category. (Fig. 10).

5.) **Repair Costs:** Repair costs on the structure is taken over 5 years. The lower the costs, the higher the value of the category. The repair costs can be based on knowing the possibility of partial or total collapse. This can be determined by a decision analysis method where the probability of the various collapse states are analyzed for each alternative. Take for example, the repair cost over 5 years for the Sacrificial Island is found to be $500,000; for the Caisson Retained Island $400,000; and for the Slope Sided Caisson Retained Island $300,000. The differences in dollar values comes from the caissons requiring less repair due to ice damage. The Slope Sided Caisson Retained Island should experience the least damage of all. Assume that, if within 5 years the repair costs exceeded $10,000,000, it is best to replace the structure. Thus, $10,000,000 is given a utility value of 0, while $0 repair costs is given a value of 1.0 (of course, the most preferred). (Fig. 11).

6.) **Relocatability:** The ability to move the island or parts of the island (ie. caissons, etc.), to another site. The easier it is to move the island, the higher value of this category. Here the Sacrificial Island is given a value of 9.0 (on a scale with 0 being high, and 10 being low); the

Caisson Retained Island was given a rating of 5.0, being easier to relocate than the Sacrificial Island; and the Slope Sided Caisson Retained Island was also given a rating of 5.0. Since a high rating reflects more difficulty in relocation, than the corresponding utility rating for a 10 is 0, while a low rating of 0 is most preferred, thereby receiving a utility rating of 1.0. (Fig.12).

7.) **Ice Force Resistance:** This is the ability for the structure to resist the ice features anticipated at the site. The larger the ice feature the structure is able to resist, the higher the utility function. Experience in determining how large an ice feature the structure can resist is required. The structures are rated on a scale from 0 to 10, with a 0 rating signifies that no ice features could be resisted, and a 10 rating signifies the largest ice feature anticipated could be resisted with only minimal damage. Let the Sacrificial Island have a rating of 4.0; the Caisson Retained Island a 6.0; and the Slope Sided Caisson Retained Island a 9.0. (Fig. 13).

8.) **Ease of Construction:** A measure of the difficulty in the construction of the structure. Takes into account such factors as work required, on site preparation, on site support, ease of workability of the materials used, etc. The easier the construction, the higher the value of this category. Corporate knowledge and experience should be consulted for this category. Take the Sacrificial Island as the easiest to construct, therefore give it a rating of 10 on a scale from 1 to 10. The Caisson Retained Island is given a rating of 5.0, since the caisson construction will cause some difficulty; and the Slope Sided Caisson Retained Island was given a rating of 2.7, since the slopes will require specialized skills. The most preferred is the easiest construction, as

this is an indicator that few specialized labor skill will be required. Therefore, a rating of 10 is given an utility of 1.0, and a 0 rating corresponds to a utility of 0. (Fig. 14).

9.) **Construction Time:** Time of on site construction, an important factor since the Arctic has seasons of short duration for construction of the islands. The shorter the time, the higher the category value. The construction time is made a function of depth. Engineering, experience, and a assumed ice-free period of 260 days dictated the acceptable time for construction. Thus, a utility of 0 relates to a 260 day construction time, (least preferred), while a 1.0 rating is for a construction time of 0 days. For the Sacrificial Island, a straight construction time of .25 days per foot of water depth is assumed. The Caisson Retained Island assumes 3 days per foot of water depth for the caisson/fill construction and erection, and 1.75 days per foot of water depth for the berm. The Slope Sided Caisson Retained Island was determine to require 6 days per foot of water depth for the caisson/fill construction and erection, and 1.75 days per foot of water depth for the berm. (Fig.15).

Preferences

Now that the utility functions have been determined for each consequence (category), it is time to weigh the consequence amongst themselves. In other words, give preference among the consequence. In this case, management might be asked to weigh on a scale from 0 to 10 the preference of each category over all the other categories. A 10 means more weighted (or preferred to) than the others. This will give which categories are most important. After all the values are given, they are normalized such that their sum equals 1.0 . Table (1) gives the preferences and the normalized values for this demonstration.

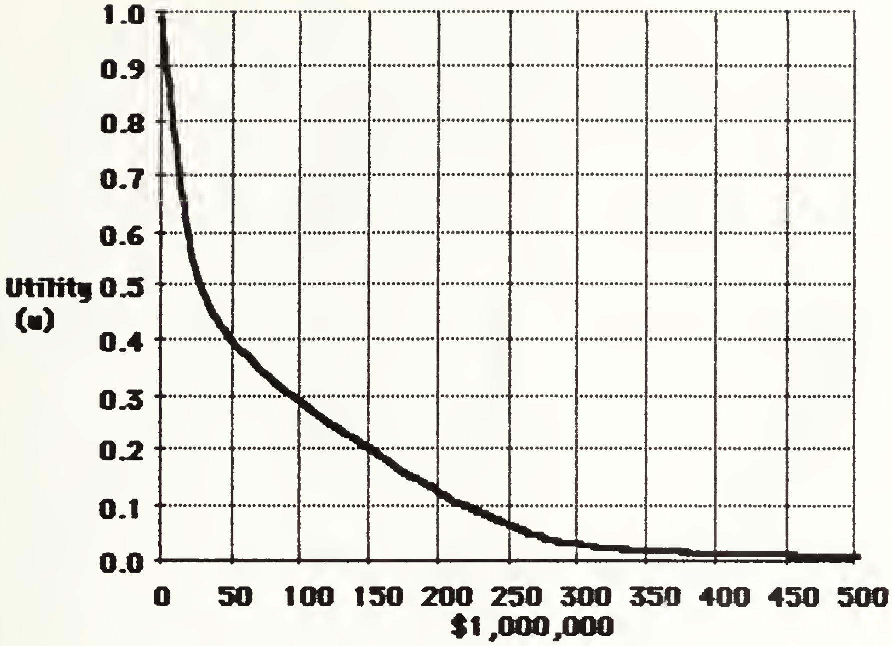

Fig. 7 Utility Values (u) for Initial Costs

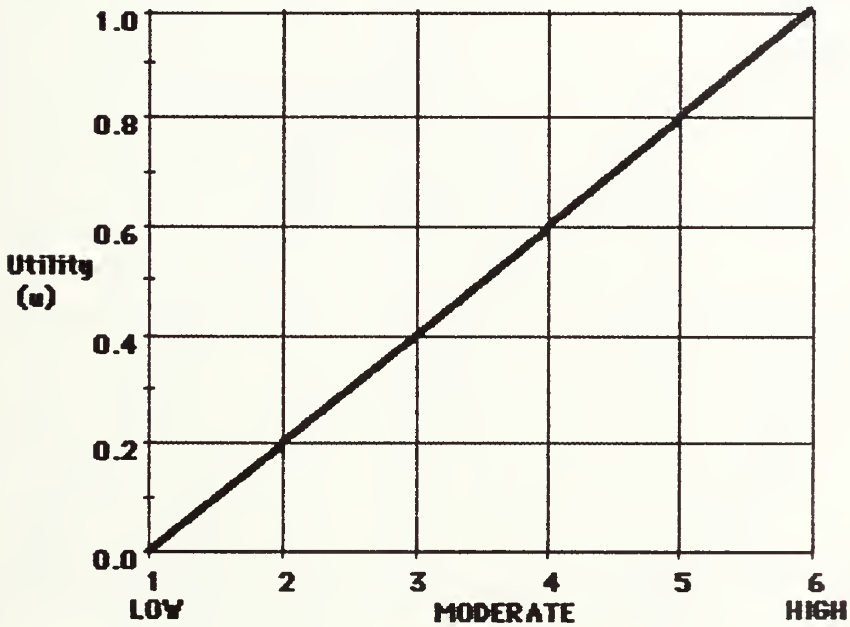

Fig. 8 Utility Values (u) for Adaptability

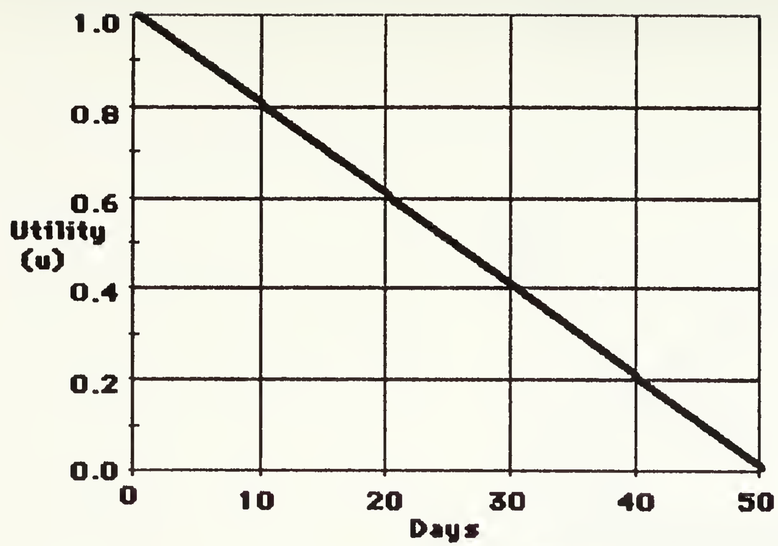

Fig. 9 Utility Values for Transit Time

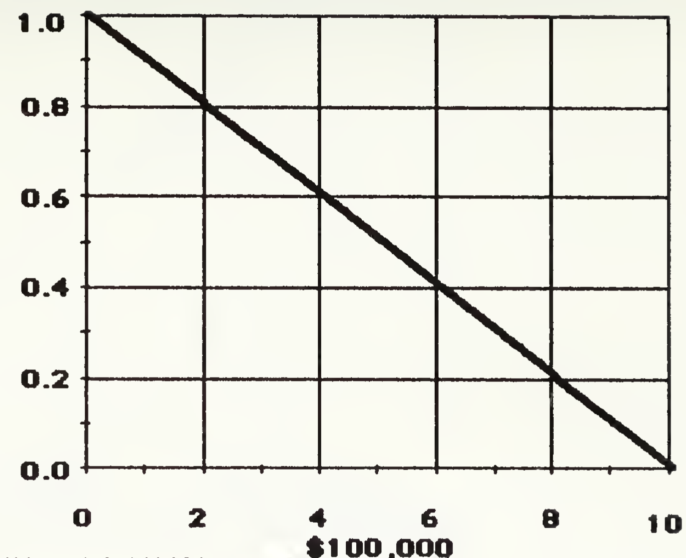

Fig. 10 Utility Values for Depreciation Costs

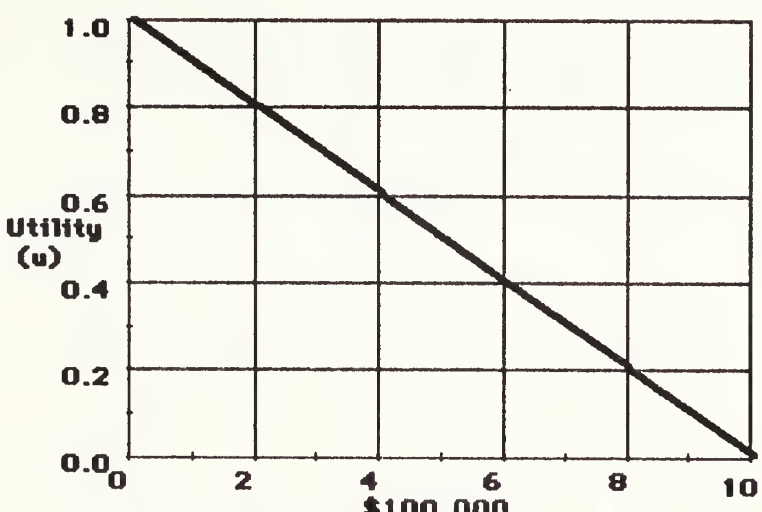

Fig. 11 Utility Values for Repair Costs

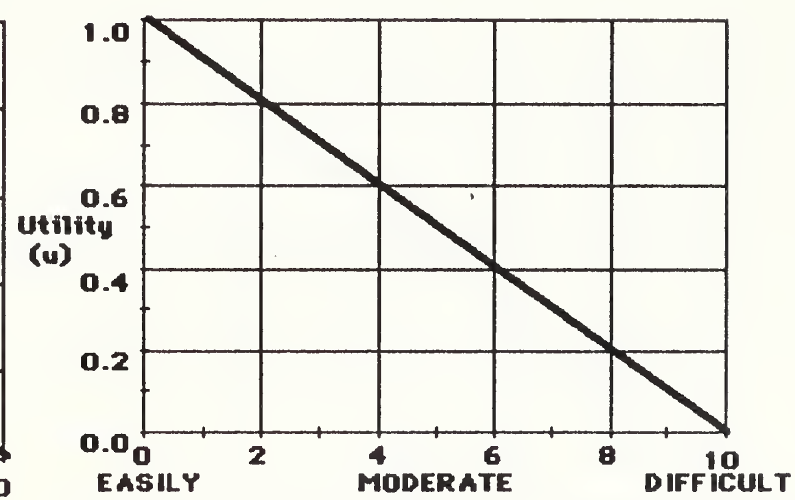

Fig. 12 Utility Values for Relocateability

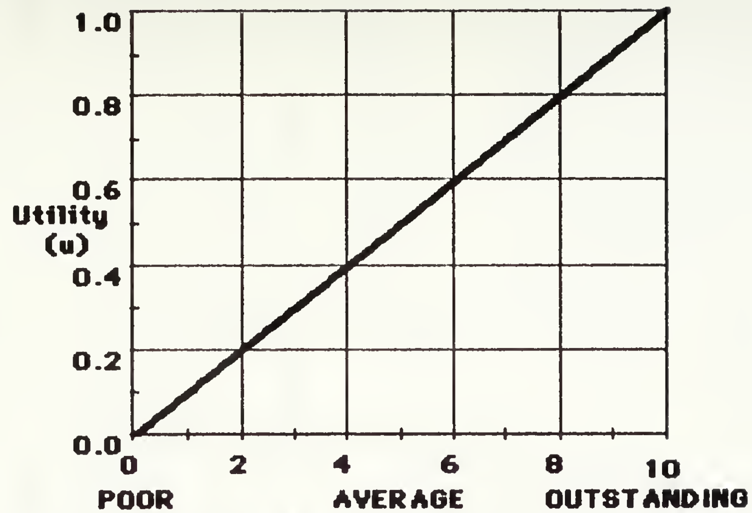

Fig. 13 Utility Values for Ice Force Resistance

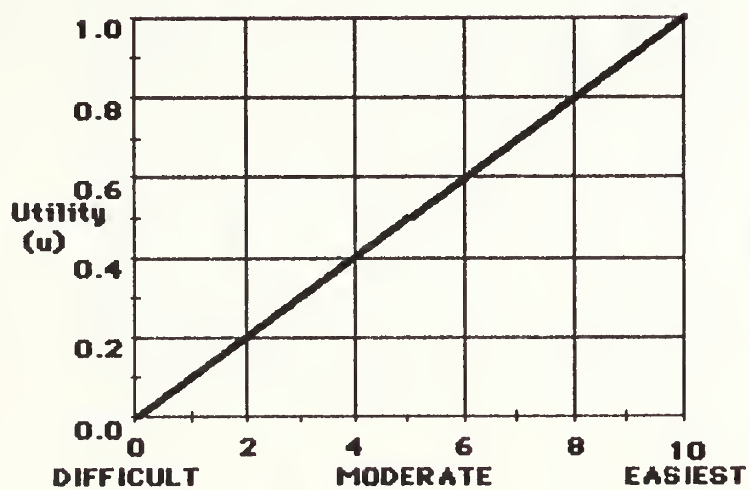

Fig. 14 Utility Values for Ease of Construction

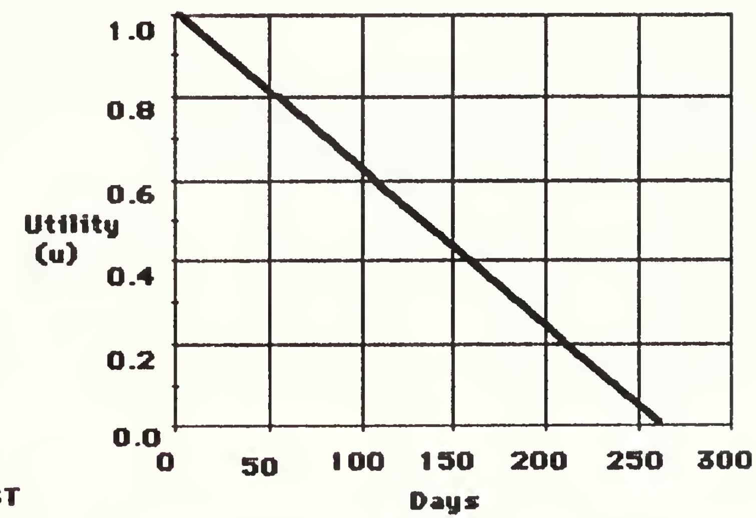

Fig. 15 Utility Values for Construction Time

Table 1: Category Preferences

CATEGORY	PREFERENCES	NORMALIZED
Initial Costs	10.0	0.16
Adaptability	5.0	0.08
Transit Time	7.0	0.11
Depreciation Costs (5 yrs)	4.0	0.06
Repair Costs (5 yrs)	6.0	0.09
Relocatability	5.0	0.08
Ice Force Resistance	10.0	0.16
Ease of Construction	8.0	0.12
Construction Time	9.0	0.14
$\Sigma =$	64.0	1.00

Probability of Occurrence

The final step is to measure how much confidence there is in the results of each category or the probability of occurrence. This way, a consequence with a low probability of occurrence will not influence the final decision as much a a consequence that is certain to happen. Here the personnel responsible for the ratings of the consequences are also interviewed for the probability of occurrence. Using probability theory, for a consequence that is sure to occur as stated, would be assigned a value of 1.0, while a consequence that has quite a bit of room for error, or is likely not to occur, would be assigned a value of 0. This may vary with each alternative, since the experience and knowledge for each alternative is not the same. For this example, table (2) gives the probability of occurrence.

Table 2: Probability of Occurance

	Sacrificial Island	Caisson Retained Island	Slope Sided Caisson Retained Island
Initial Costs	.6	.6	.6
Adaptability	.7	.7	.7
Transit Time	.5	.5	.5
Depreciation Costs (5 yrs)	.7	.7	.7
Repair Costs (5yrs)	.4	.4	.4
Relocatability	.4	.4	.4
Ice Force Resistance	.9	.9	.9
Ease of Construction	.8	.8	.8
Construction Time	.6	.6	.6

In order to calculate the Expected Utility, E[U], first find the associated Utility Ratings, (u), from the charts developed for each alternatives' consequence rating. Multiply the Utility Rating by the preference for that alternative, k, this gives the Utility [U]. Now multiply the Utility by the Probability of Occurrence, p, which will give the Expected Utility for each consequence. Last add all the Expected Utilities for each consequence for each alternative. In other words, the Expected Utility of an alternative is, (in our case the Expected Utility for each type of Island studied for each depth considered):

$$\Sigma E[U]_i = \Sigma(k_i \times u_i \times p_i) \text{ ....} (3)$$

where: $U_i = (u_i k_i)$

for i=number of consequences considered per alternative

Evaluation

The higher the expected utility, the more favored the alternative. As can be seen from figure (16), it would appear for a water depth of 20 feet that the sacrificial island or the caisson retained island is the best choice. However, this is only for initial costs, when considering all the categories, along with the preferences assigned, figure (17) shows that the optimum alternative is the Slope Sided Caisson Retained Island. In other words, for the conditions as stated, the extra initial costs will benefit in a better suited structure for the site. In the cases where the expected utilities are equal, another form of evaluation is required. To aid in drawing a conclusive conclusions, a sensitivity analysis ought to be performed. In particular, sensitivity of the consequences and their likelihood of occurrences, along with the preferences on the ranking of the alternatives should be analyzed for their influences on the expected utility.

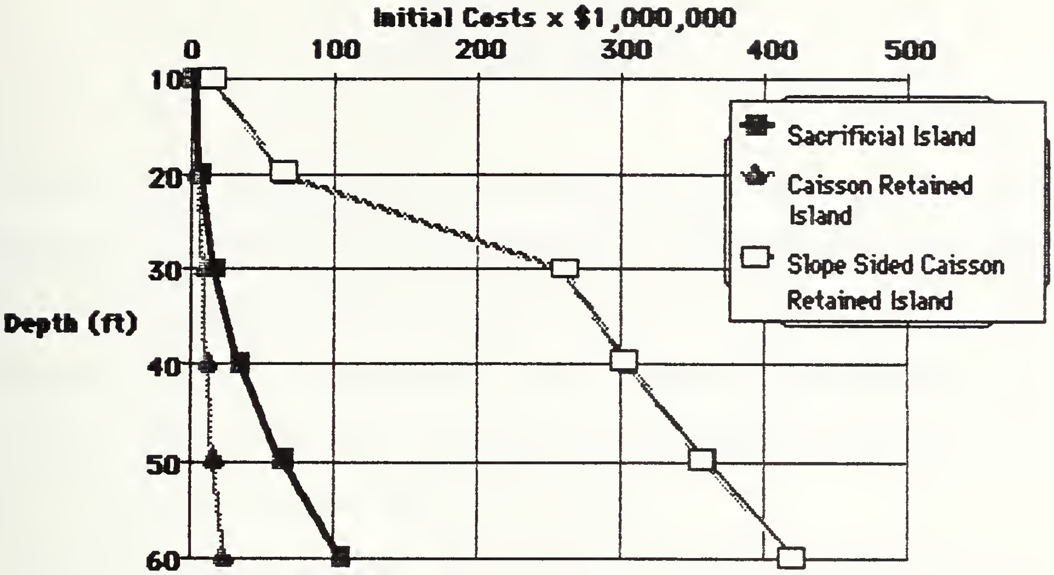

Fig. 16 Island Initial costs as a Function of Water Depth

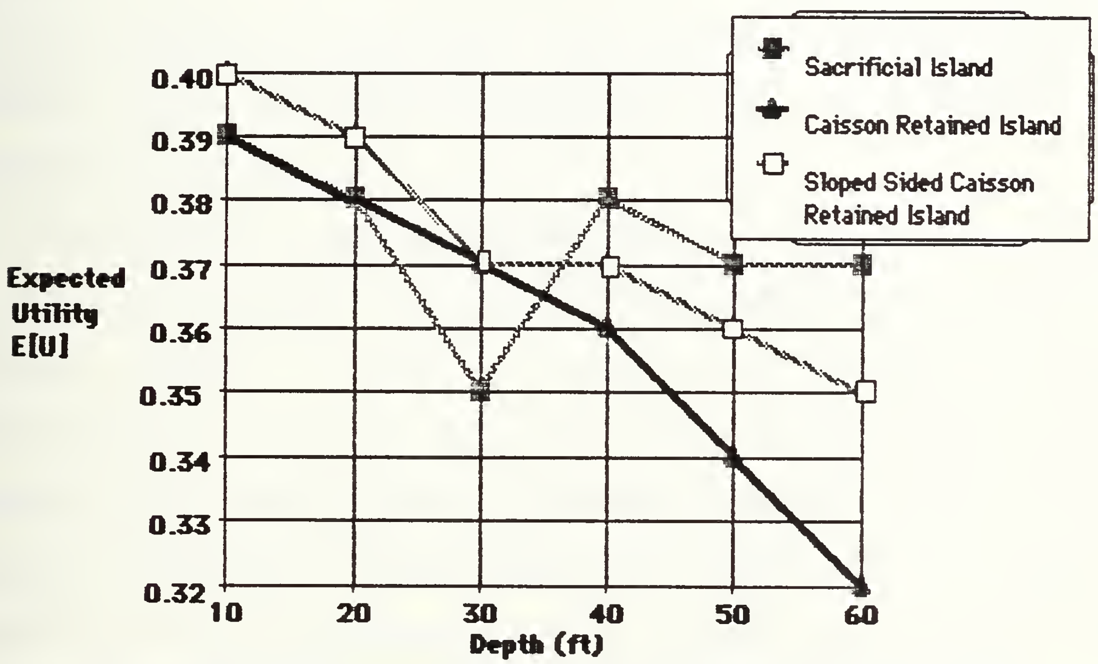

Fig. 17 Island Expected Utility as a Function of Water Depth

CHAPTER IV

CONCLUSIONS

It has been demonstrated that given several alternatives, with their consequences and likelihoods of occurrence, a systematic methodology was developed that enable decision makers to draw conclusions as to which alternatives is the best selection. Even if these consequences might be subjective in nature, and with no common data base (ie. dollars for initial costs is compared against transit time in days).

Decision analysis gives no supernatural way for predicting the correct decision. In fact, it forces the decision maker to rely more than ever on his own judgments and preferences. Decision analysis actually formalizes "common sense" by means of alternatives, value (utility theory), and probability of occurrence.

The real power to decision analysis is its ability to lend itself easily to a sensitivity analysis. By using the multiattribute utility function, it becomes possible to define the value of the tradeoff constants (preferences) for which the ranking of the alternatives changes (by the changing of the expected utility). Additional considerations should be the changes in likelihoods of each consequence, changes in the consequences themselves that are associated with each alternative, and changes in the individual attributes for determining the utility functions.

In summary, decision analysis provides a powerful tool for evaluating the risk impact in a variety of offshore engineering decisions, from the simplest, to the most complex problems.

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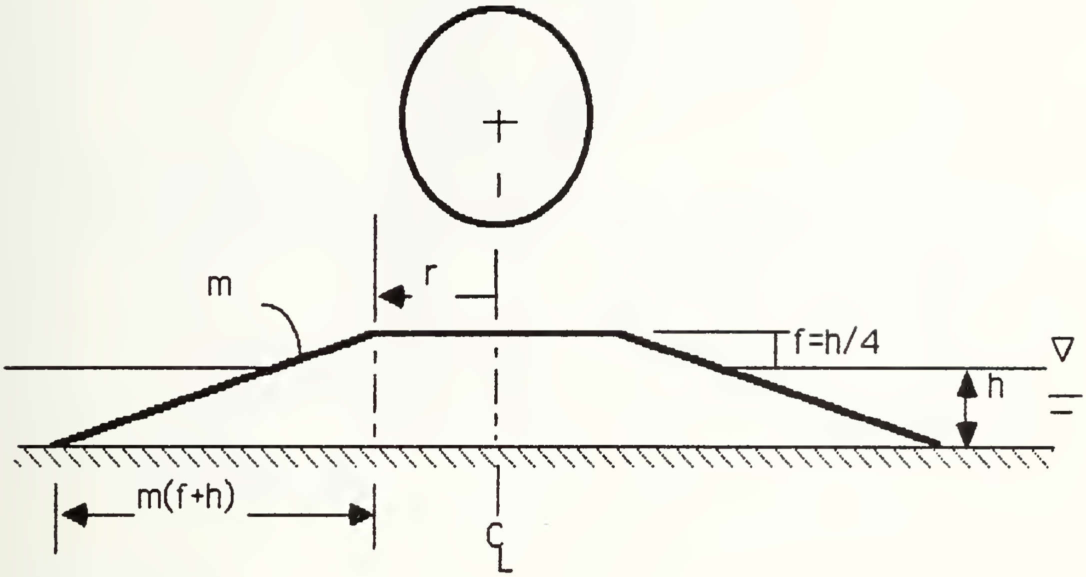
APPENDIX A

EQUATIONS FOR AMOUNT OF FILL AND CONCRETE REQUIRED

Presents the equations used for the initial costs category.

For the SACRIFICIAL ISLAND :



where:

r=radius of berm

f=freeboard

h=waterdepth

m=slope of berm

Fig. A1 Sacrificial Arctic Island

The equations developed for the costs of land fill as a function of depth are:

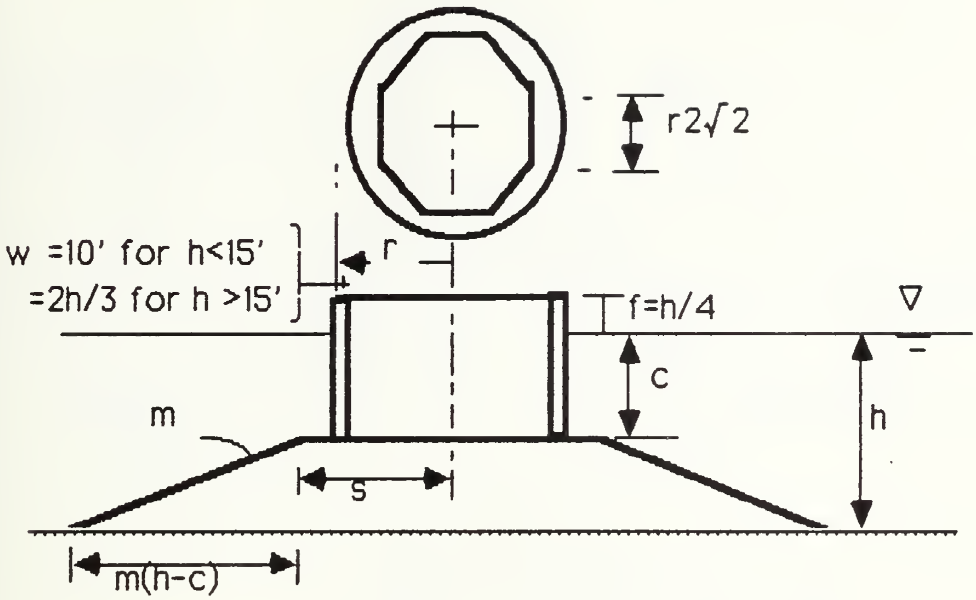
$$\text{Volume of Fill} = \pi/3(\text{height})[(\text{top radius})^2 + (\text{bottom radius})^2 + (\text{top radius})(\text{bottom radius})]$$

$$= (\pi/3)(h+f)\{[r+m(h+f)]^2 + r^2 + r[r+m(h+f)]\}$$

$$= (\pi/3)(h+f)[3r^2 + 3rm(h+f)+[m(h+f)]^2\}$$

$\therefore$ cost of Island = (volume of fill)(cost of fill)

For the CAISSON RETAINED ISLAND :



where:

c=depth of caisson below water level

w=width of caisson

s=radius of berm

Fig. A2 Caisson Retained Island

The equations developed for the costs of material as a function of depth are:

volume of concrete = 8(length of side)(height of caisson)(width)

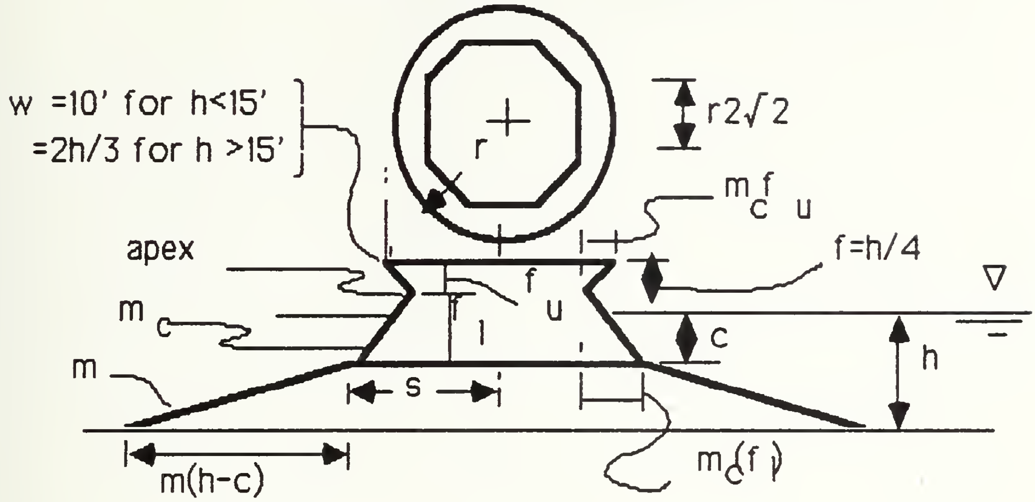
$= 8(2\sqrt{2})r(c+f)w$

volume of fill = volume of caisson fill + volume of berm

$= (8\sqrt{2})r^2(c+f) + (\pi/3)(h-c)[3s^2 + 3sm(h-c)+[m(h-c)]^2\}$

$\therefore$ cost of Island = (volume of concrete)(cost of concrete) + (volume of fill)(cost of fill)

For the SLOPE SIDED CAISSON RETAINED ISLAND :



where: m_c=slope of caisson
f_u=height of caisson above apex
f_l=height of caisson below abex
=$(c+f-f_u)$

Fig. A3 Slope Sided Caisson Retained Island

The costs of materials are derived by;

volume of fill = volume of caisson fill above apex + volume of caisson fill below apex + volume of berm

$$= 8\sqrt{2}(r-m_cf_u)^2f_u + {}^1/_2(m_cf_u)f_u2\sqrt{2}[r+ {}^1/_2(m_cf_u)]8$$

$$+ 8\sqrt{2}(r-m_cf_u)^2f_l + {}^1/_2(m_lf_l)f_l2\sqrt{2}[r+ {}^1/_2(m_cf_l)]8$$

$$+ (\pi/3)(h-c)[3s^2 + 3sm(h-c)+[m(h-c)]^2\}$$

$$\therefore \text{volume of fill} = (8\sqrt{2})f_u[r^2 + m_cf_u({}^3/_2m_cf_u-r)]$$

$$+ (8\sqrt{2})f_l[(r-m_cf_u)^2 + m_cf_l(1/_2m_cf_l + r)]$$

$$+ (\pi/3)(h-c)[3s^2 + 3sm(h-c)+[m(h-c)]^2\}$$

volume of concrete = volume of caisson above apex + volume of caisson below apex

$$= {}^1/_2[(2\sqrt{2})r + (2\sqrt{2})(r-m_cf_u)]8[f_u^2 + (m_cf_u)^2]w$$

$$+ {}^1/_2[(2\sqrt{2})(r-m_cf_u)$$

$$+(2\sqrt{2})(r-m_cf_u+m_cf_l)]8[f_l^2 + (m_cf_l)^2]w$$

$$\therefore \text{volume of concrete} = (8\sqrt{2})w[f_u^2+(m_cf_u)^2](2r-m_cf_u) + (8\sqrt{2})w[f_l^2+(m_cf_l)^2][2(r-m_cf_u)+m_cf_l]$$

APPENDIX B

COMPUTERPROGRAM

A digital computer program that:

1.) Allows the input of utility graphs

2.) Calculates the utilities, given preferences and utility ratings

3.) Calculates the Expected Utility, given the probability of occurrence

4.) Calculates the total Expected Utility for each category

```
      PROGRAM EXAMPLE(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C
C*********************************************************************
C*     AFTER INPUTTING THE UTILITY GRAPHS, THE PREFERENCE FOR THE          *
C*     CATEGORIES, AND THE UTILITIES OF EACH CATEGORY FOR EVERY            *
C*     STRUCTURE, THIS PROGRAM WILL CALCULATE THE EXPECTED UTILITY.        *
C*     FURTHER, AFTER INPUTTING THE REQUIRED PHYSICAL                      *
C*     CHARACTERISTICS, THIS PROGRAM WILL CALCULATE THE MANUFACTURE        *
C*     COSTS                                                               *
C*                                                                         *
C*     NOTE:  THE INITIAL COSTS CATEGORY MUST BE ENTERED FIRST FOR THE     *
C*     UTILITY GRAPHS.  AFTER THE INITIAL COSTS GRAPH IS ENTERED, THEN     *
C*     ANY OTHER GRAPHS MAY BE ENTERED UP TO 50 CATEGORIES.                *
C*     EACH UTILITY GRAPH MUST BE ENTERED IN THE ORDER OF                  *
C*     U=0.0 TO U=1.0                                                      *
C*********************************************************************
C
C    DIMENSION STATEMENTS
C
      CHARACTER*40, GRANAM(51)
      REAL UGRAPH(15,51),PREF(51),UTIL(51),PROB(51),F,M,S,R,MC,FU,FL,C,H
      INTEGER NG,I,J,K
C
C**************************VARIABLE LISTS**************************
C     GRANAM=NAME OF THE UTILITY GRAPH, MAX OF 50
C     NG=NUMBER OF UTILITY GRAPHS
C     UGRAPH=VALUES OF UTILITIES GRAPHS, MUST INPUT SIX VALUES IN ORDER
C        FROM U=0 TO U=1.0
C     PREF=PREFERENCE OF UTILITY CATEGORIES
C     H=DEPTH OF WATER
C     F=FREEBOARD OF ISLAND ABOVE SEA LEVEL (FT)
C     M=AVG SLOPE OF BERM, INPUT SECOND PART OF RATIO (IE. 1:XXX)
C     R=RADIUS,(OR EQUIV. RADIUS), OF PLATFORM (FT)
C     C=DEPTH OF CAISSON BELOW SEA LEVEL, (FT)
C     S=RADIUS OF BERM BELOW CAISSON (FT)
C     MC=AVG SLOPE OF CAISSON, ASSUMES A SYMMETRICAL SLOPE OF A
C     SLOPE SIDED CAISSON--INPUT THE SAME AS FOR M
C     FU=VERTICAL DISTANCE OF SLOPE SIDED CAISSON ABOVE APEX (FT)
C     FL=VERTICAL DISTANCE OF SLOPE SIDED CAISSON BELOW APEX (FT
C     CCOST=CONCRETE COSTS  ($/CUBIC YARD)
C     FCOST=FILL COSTS   ($/CUBIC YARD
C     UTIL=UTILITY
C
C*********************************************************************
C
C     INTIALIZE
C
      SUM=0
      W=0
      PI=3.1416
C
C*********************************************************************
C
C    INPUT THE NUMBER OF GRAPHS, THE COST OF CONCRETE,THE COST OF FILL
C
  50  FORMAT(I5,2F10.2)
```

```
      READ 50,NG,CCOST,FCOST
C
C     INPUT GRAPH NAMES, AND PREFERENCES
      DO 92 I=1,NG
 90   FORMAT(A40,F10.2)
      READ 90,GRANAM(I),PREF(I)
 92   CONTINUE
      GRANAM(NG+1)='UTILITY RATING'
C    CHECK TO INSURE THE SUM OF THE PREFERENCES ADDS UP TO ONE
      DO 120 I=1,NG
      SUM=SUM+PREF(I)
 120  CONTINUE
      IF (SUM.NE.1.)THEN
      PRINT*,'SUM OF ALL PREFERENCES MUST ADD UP TO ONE, CHECK DATA'
      GOTO 500
      ENDIF
C
C*****************************************************************
C
C     INPUT THE UTILITY GRAPH VALUES
 100  FORMAT(11F7.2)
      READ 100,((UGRAPH(I,J),J=1,11),I=1,NG)
C
C     SET THE LAST ROW OF ARRAY AS THE UTILITY AXIS
      UGRAPH(NG+1,1)=0
      DO 105 I=2,11
      UGRAPH(NG+1,I)=UGRAPH(NG+1,I-1)+.1
      105 CONTINUE
C
C**************INPUT FOR SACRIFICIAL ISLAND*****************************
C
      150 FORMAT(2F10.2)
      READ 150,M,R
C     INPUT PROBABILITIES OF OCCURRENCE AND UTILITY VALUES
 155  FORMAT (9F5.2)
      READ 155,(UTIL(I),I=1,NG)
      READ 155,(PROB(I),I=1,NG)
C*****************************************************************
C
 164  FORMAT(//)
 PRINT 164
C
      DO 167 K=10,60,10
      H=FLOAT(K)
      F=H/4
C     CONSTRUCTION TIME=0.25 DAYS/FOOT OF DEPTH
      UTIL(NG)=0.25*H
C   CALCULATE AMOUNT OF FILL
      VOLFIL=(PI/3)*(H+F)*((3*(R**2))+(3*R*M*(H+F))+((M*(H+F))**2))
C    CONVERT FROM CUBIC FEET TO CUBIC YARDS
      VOLFIL=VOLFIL/27
      TOTCOS=VOLFIL*FCOST
      PRINT 164
      PRINT *,'***************SACRIFICIAL ISLAND***************'
      PRINT 164
 165  FORMAT (A22,F10.2,1X,A2)
      PRINT 165,'WATER DEPTH:',H,'FT'
      PRINT 165,'ISLAND FREEBOARD:',F,'FT'
```

```
      PRINT 165,'AVG. SLOPE OF BERM  1:',M,' '
      PRINT 165,'RADIUS OF DECK:',R,'FT'
      CALL GFUN(TOTCOS,UGRAPH,PREF,GRANAM,NG,UTIL,PROB)
  167 CONTINUE
C
C*********INPUT DATA FOR CAISSON RETAINED ISLAND***********************
C
  169 FORMAT(3F10.2)
      READ 169,M,R,S
C   INPUT PROBABILITIES OF OCCURRENCE AND UTILITY VALUES
  170 FORMAT (9F5.2)
      READ 170,(UTIL(I),I=1,NG)
      READ 170,(PROB(I),I=1,NG)
C*********************************************************************
C
  174 FORMAT(//)
      PRINT 174
C
      DO 185 K=10,60,10
      H=FLOAT(K)
C     ASSUMES MAX DEPTH OF CAISSON IS 30 FEET
      F=H/4
      IF (H.LE.30) THEN
      C=H
C    CONSTRUCTION TIME FOR CAISSON=3 DAYS/FOOT OF DEPTH
      UTIL(NG)=3*H
      GOTO 175
      ENDIF
      C=30
C     CONSTRUCTION TIME= 90 DAY FOR CAISSON+1.75 DAYS/FOOT FOR FILL
      UTIL(NG)=90+1.75*(H-C)
  175 IF(H.LT.15) THEN
      W=10
C    ASSUMES WIDTH OF CAISSON IS MIN OF 10 FT
      GOTO 176
      ENDIF
      W=2*C/3
C     CALCULATE FILL AND CONCRETE COSTS
  176 VOLFIL=8*1.41421*(R**2)*(C+F)+(PI/3)*(H-C)*((3*(S**2))
     &   +(3*S*M*(H-C))+((M*(H-C))**2))
      VOLCON=8*W*2*1.41421*R*(C+F)
C    CONVERT FROM CUBIC FEET TO CUBIC YARDS
      VOLFIL=VOLFIL/27
      VOLCON=VOLCON/27
C     COSTS
 TOTCOS=VOLFIL*FCOST+VOLCON*CCOST
      PRINT 174
      PRINT *,'***************CAISSON RETAINED ISLAND****************'
      PRINT 174
  182 FORMAT (A22,F10.2,1X,A2)
      PRINT 182,'WATER DEPTH:',H,'FT'
      PRINT 182,'CAISSON FREEBOARD:',F,'FT'
      PRINT 182,'AVG. SLOPE OF BERM  1:',M,' '
      PRINT 182,'1/2 DECK WIDTH:',R,'FT'
      PRINT 182,'DRAFT OF CAISSON:',C,'FT'
      PRINT 182,'BERM RADIUS:',S,'FT'
      CALL GFUN(TOTCOS,UGRAPH,PREF,GRANAM,NG,UTIL,PROB)
  185 CONTINUE
```

```
C
C*********INPUT DATA FOR SLOPE SIDED CAISSON RETAINED ISLANDS**********
C
  186  FORMAT(5F10.2)
       READ 186,M,R,S,MC,FU
C   INPUT PROBABILITIES OF OCCURRENCE AND UTILITY VALUES
  187  FORMAT (9F5.2)
       READ 187,(UTIL(I),I=1,NG)
       READ 187,(PROB(I),I=1,NG)
C*******************************************************************
C
  191  FORMAT(//)
       PRINT 191
C
       DO 206 K=10,60,10
       H=FLOAT(K)
       F=H/4
C    ASSUMES MAX DEPTH OF CAISSON IS 30 FEET
       IF (H.LE.30) THEN
       C=H
C     CONSTRUCTION TIME=6 DAYS/FOOT OF DEPTH FOR SLOPED CAISSON
       UTIL(NG)=6*H
       GOTO 194
       ENDIF
       C=30
C    CONSTRUCTION TIME=180 DAYS FOR CAISSON+1.75 DAYS/FOOT FOR FILL
       UTIL(NG)=180+1.75*(H-C)
  194   IF(H.LT.15) THEN
       W=10
C    ASSUMES WIDTH OF CAISSON IS MIN OF 10 FT
       GOTO 195
       ENDIF
       W=2*C/3
C    CALCULATE FILL AND CONCRETE COSTS
  195  FL=C+F-FU
       VOLFIL=8*1.41421*FU*((R**2)+MC*FU*((3/2)*MC*FU-R))
     &     +8*1.41421*FL*(((R-MC*FU)**2)+MC*FL*(R+(1/2)*MC*FL))
     &     +(PI/3)*(H-C)*((3*(S**2))+(3*S*M*(H-C))+((M*(H-C))**2))
       VOLCON=8*W*1.41421*((FU**2)+((MC*FU)**2))*(2*R-MC*FU)
     &     +8*W*1.41421*((FL**2)+((MC*FL)**2))*((2*(R-MC*FU))+MC*FL)
C    CONVERT FROM CUBIC FEET TO CUBIC YARDS
       VOLFIL=VOLFIL/27
       VOLCON=VOLCON/27
C     COSTS
       TOTCOS=VOLFIL*FCOST+VOLCON*CCOST
       PRINT 191
       PRINT *,'**********SLOPE SIDED CAISSON RETAINED ISLAND**********'
       PRINT 191
  202  FORMAT (A22,F10.2,1X,A2)
       PRINT 202,'WATER DEPTH:',H,'FT'
       PRINT 202,'CAISSON FREEBOARD:',F,'FT'
       PRINT 202,'AVG. SLOPE OF BERM  1:',M,' '
       PRINT 202,'1/2 DECK WIDTH:',R,'FT'
       PRINT 202,'DRAFT OF CAISSON:',C,'FT'
       PRINT 202,'BERM RADIUS:',S,'FT'
       PRINT 202,'CAISSON SLOPE  1:',MC,' '
  204  FORMAT (A28,F10.2,1X,A2)
       PRINT 204,'HEIGHT OF CAISSON ABOVE APEX:',FU,'FT'
```

```
      PRINT 204,'DEPTH OF CAISSON BELOW APEX:',FL,'FT'
      CALL GFUN(TOTCOS,UGRAPH,PREF,GRANAM,NG,UTIL,PROB)
 20   CONTINUE
 500  STOP
      END
C*******************************************************************
C*               SUBROUTINE GFUN                                   *
C*******************************************************************
C
      SUBROUTINE GFUN(TOTCOS,UGRAPH,PREF,GRANAM,NG,UTIL,PROB)
C    DIMENSION STATEMENTS
      CHARACTER*40,GRANAM(51)
      REAL UGRAPH(15,51),PREF(51),UPRIM(51),UTIL(51),PROB(51)
C
 296  FORMAT (A15,F15.2)
      PRINT 296,'TOTAL COSTS = $',TOTCOS
      PRINT *
 298  FORMAT(33X,A11,7X,A7,8X,A9,4X,A14,5X,A8)
      PRINT 298,'PREFERENCES','UTILITY','UTILITIES','PROBABILITY OF',
     &      'EXPECTED'
 299  FORMAT(38X,A3,10X,A11,8X,A3,11X,A9,4X,A14)
      PRINT 299,'(K)','RATINGS (U)','[U]','OCCURRENCE','UTILITIES E[U]'
      PRINT *
      UTIL(1)=TOTCOS/1000000
C     NOTE:THE FIRST GRAPH MUST BE 'INITIAL COSTS'
C
C    GRAPH INTERPOLATION
C    CHECK TO SEE IF GRAPH IS POSITIVE OR NEGATIVE
      DO 350 I=1,NG
      IF (UGRAPH(I,1).EQ.0) THEN
      GOTO 310
      ENDIF
      GOTO 330
C    POSITIVE SLOPE INTERPOLATION
 310  IF (UTIL(I).GT.UGRAPH(I,11)) THEN
      UTIL(I)=UGRAPH(I,11)
      PRINT*,'UTILITY VALUE IS GREATER THAN GRAPH VALUE'
     &     ,' INPUTS FOR CATEGORY ',GRANAM(I)
      GOTO 340
      ENDIF
      GOTO 340
C    NEGATIVE SLOPE INTERPOLATION
 330  IF(UTIL(I).GT.UGRAPH(I,1)) THEN
      UTIL(I)=UGRAPH(I,1)
      PRINT*,'UTILITY VALUE IS GREATER THAN GRAPH VALUE'
     &     ,' INPUTS FOR CATEGORY ',GRANAM(I)
      GOTO 340
 ENDIF
 340  DO 342 J=1,11
      IF (UTIL(I).GE.UGRAPH(I,J)) THEN
      GOTO 345
      ENDIF
 342  CONTINUE
 345  IF (UTIL(I).EQ.UGRAPH(I,J)) THEN
      UPRIM(I)=UGRAPH(NG+1,J)
      GOTO 350
      ENDIF
      IF(UGRAPH(I,1).NE.0) THEN
```

```
      UPRIM(I)=((UGRAPH(NG+1,J)-UGRAPH(NG+1,J-1))/
     &        (UGRAPH(I,J)-UGRAPH(I,J-1)))*UTIL(I)+1.0
      GOTO 350
      ENDIF
      UPRIM(I)=((UGRAPH(NG+1,J+1)-UGRAPH(NG+1,J))/
     &        (UGRAPH(I,J+1)-UGRAPH(I,J)))*UTIL(I)
  350 CONTINUE
C
C    PRINT OUT FINAL CHART
      DO 370 I=1,NG
  360 FORMAT(A31,3X,F6.2,4(10X,F6.2))
      PRINT 360,GRANAM(I),PREF(I),UPRIM(I),UPRIM(I)*PREF(I),PROB(I),
     &         UPRIM(I)*PREF(I)*PROB(I)
  370 CONTINUE
C    SUMMATION OF UTILITIES AND OF EXPECTED UTILITIES
      SUPRIM=0
      EXPUTL=0
      DO 380 I=1,NG
      SUPRIM=SUPRIM+UPRIM(I)*PREF(I)
      EXPUTL=EXPUTL+UPRIM(I)*PREF(I)*PROB(I)
  380 CONTINUE
  385 FORMAT(65X,A8,24X,A8)
      PRINT 385,'---------','--------'
  390 FORMAT(62X,A4,F6.2,22X,A4,F6.2)
      PRINT 390,'SUM=',SUPRIM,'SUM=',EXPUTL
      PRINT *
      RETURN
      END
```

APPENDIX C

OUTLINE of COMPUTER DATA INPUT

Shows how data is to be formatted

GENERAL INPUT

```
23|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
2F10.2| NG      | CCOST     | FCOST   |
10,F10.2|          GRANAM                 | PREF     |
                    :                         :
                    :                         :
              FOR HOWEVER MANY GRAPHS THERE ARE (NG)
                    :                         :
                    :                         :
```

UGRAPH INPUT (UGRAPH)

```
23|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
F7.2  |FOR U=0  | U=0.1 | U=.2 | U=.3  | U=.4    | U=.5 | U=.6  | U=.7   | U=.8  | U=.9 | U=1.0 |
                    :                         :
                    :                         :
              FOR HOWEVER MANY GRAPHS THERE ARE (NG)
                    :                         :
                    :                         :
```

SACRIFICIAL ISLAND

Input for Island dimensions

```
23|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
F10.2 |      M     |     R     |
```

Input for Utility Values

```
23|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
G)F5.2 |UTIL 1 | ......FOR HOWEVER MANY NUMBER OF GRAPH THERE ARE.................|UTIL NG|
```

Input for Probabilities of Occurrence

```
23|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
G)F5.2 |PROB 1  | ......FOR HOWEVER MANY NUMBER OF GRAPH THERE ARE.................|UTIL NG|
```

CAISSON RETAINED ISLAND

Input for Island dimensions

```
23|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
F10.2 |      M     |     R     |     S     |
```

Input for Utility Values

```
23|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
G)F5.2 |UTIL 1 | ......FOR HOWEVER MANY NUMBER OF GRAPH THERE ARE.................|UTIL NG|
```

Input for Probabilities of Occurrence

```
23|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
G)F5.2 |PROB 1  | ......FOR HOWEVER MANY NUMBER OF GRAPH THERE ARE.................|UTIL NG|
```

SLOPE SIDED CAISSON RETAINED ISLAND

Input for Island dimensions

```
2|3|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
7102 |    M    |    R    |    S    |    MC    |    FU    |
```

Input for Utility Values

```
2|3|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
     | UTIL 1 | ......FOR HOWEVER MANY NUMBER OF GRAPH THERE ARE...............|UTIL NG|
```

Input for Probabilities of Occurrence

```
2|3|4|5|6|7| | |10|||||||||20|||||||||30|||||||||40|||||||||50|||||||||60|||||||||70|||||||||80|||||||||90|
     | PROB 1  | ......FOR HOWEVER MANY NUMBER OF GRAPH THERE ARE...............|UTIL NG|
```

:   :

:   :

FOR HOWEVER MANY ALTERNATIVES THERE ARE

:   :

:   :

efinitions:

NG: Number of consequences (the number of utility graphs inputted)

CCOST: Concrete costs (in place costs)

FCOST: Fill costs (includes all costs associated with dredging and placing)

GRANAM: Graph names (up to 40 characters long)

PREF: Preferences for each consequence (sum of all preferences must = 1.0)

UGRAPH: Horiz. axis of utility function graphs (start for u=0.0 to u=1.0 at left)
NOTE: First graph must be Initial costs and last graph must be Construction Time

M: Slope of berm (1:xxxxxxx.xx where M = xxxxxxx.xx)

R: Equivalent radius (ie. radius of circle inscribed on platform in ft)

UTIL: Utilities for each consequence (graph)

PROB: Probability of Occurrence for each consequence (graph)

S: Radius of berm below caisson (ft)

MC: Slope of caisson (1:xxxxxxx.xx where M = xxxxxxx.xx)

FU: Height of caisson above apex (ft)

APPENDIX D

COMPUTERDATAINPUT

Shows the data for example problem

9	55.	12.

INITIAL COST	.16
ADAPTABILITY	.08
TRANSIT TIME	.11
DEPRECIATION COSTS (5 YRS)	.06
REPAIR COSTS (5 YRS)	.09
RELOCATABILITY	.08
ICE FORCE RESISTANCE	.16
EASE OF CONSTRUCTION	.12
CONSTRUCTION TIME	.14

500.	212.	150.	90.	57.4	25.	20.	16.	12.	7.	0.
0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
50.	45.	40.	35.	30.	25.	20.	15.	10.	5.	0.
10.	9.	8.	7.	6.	5.	4.	3.	2.	1.	0.
10.	9.	8.	7.	6.	5.	4.	3.	2.	1.	0.
10.	9.	8.	7.	6.	5.	4.	3.	2.	1.	0.
0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
260.	234.	208.	182.	156.	130.	104.	78.	52.	26.	0.

20.	150.							
0.	0.	30.	5.8	5.	9.	4.	10.	0.
.6	.7	.5	.7	.4	.4	.9	.8	.6
20.	150.	200.						
0.	4.	35.	4.3	4.	5.	6.	5.	0.
.6	.7	.5	.7	.4	.4	.9	.8	.6
20.	150.	250.	1.	9.				
0.	4.	35.	3.8	3.	5.	9.	2.7	0.
.6	.7	.5	.7	.4	.4	.9	.8	.6

APPENDIX E

COMPUTERDATAOUTPUT

Shows the data output for the example

***************SACRIFICIAL ISLAND***************

WATERDEPTH:	10.00 FT
ISLAND FREEBOARD:	2.50 FT
AVG. SLOPE OF BERM 1:	20.00
RADIUS OF DECK:	150.00 FT
TOTALCOSTS = $ 1410811.11	

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.98	.16	.60	.09
ADAPTABILITY	.08	.00	.00	.70	.00
TRANSIT TIME	.11	.40	.04	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.42	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.50	.05	.40	.02
RELOCATABILITY	.08	.10	.01	.40	.00
ICE FORCE RESISTANCE	.16	.40	.06	.90	.06
EASE OF CONSTRUCTION	.12	1.00	.12	.80	.10
CONSTRUCTIONTIME	.14	.99	.14	.60	.08
			--------		--------
			SUM= .60		SUM= .39

***************SACRIFICIAL ISLAND***************

WATERDEPTH:	20.00 FT
ISLAND FREEBOARD:	5.00 FT
AVG. SLOPE OF BERM 1:	20.00
RADIUS OF DECK:	150.00 FT
TOTALCOSTS = $	6312288.89

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.91	.15	.60	.09
ADAPTABILITY	.08	.00	.00	.70	.00
TRANSIT TIME	.11	.40	.04	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.42	.03	.70	.02
REPAIR COSTS (5'YRS)	.09	.50	.05	.40	.02
RELOCATABILITY	.08	.10	.01	.40	.00
ICE FORCE RESISTANCE	.16	.40	.06	.90	.06
EASE OF CONSTRUCTION	.12	1.00	.12	.80	.10
CONSTRUCTIONTIME	.14	.98	.14	.60	.08
			--------		--------
			SUM= .59		SUM= .38

***************SACRIFICIAL ISLAND***************

WATERDEPTH:	30.00 FT
ISLAND FREEBOARD:	7.50 FT
AVG. SLOPE OF BERM 1:	20.00
RADIUS OF DECK:	150.00 FT

TOTALCOSTS = $ 16886100.00

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.58	.09	.60	.06
ADAPTABILITY	.08	.00	.00	.70	.00
TRANSIT TIME	.11	.40	.04	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.42	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.50	.05	.40	.02
RELOCATABILITY	.08	.10	.01	.40	.00
ICE FORCE RESISTANCE	.16	.40	.06	.90	.06
EASE OF CONSTRUCTION	.12	1.00	.12	.80	.10
CONSTRUCTIONTIME	.14	.97	.14	.60	.08
			--------		--------
			SUM= .53		SUM= .35

***************SACRIFICIAL ISLAND***************

WATERDEPTH:	40.00 FT
ISLAND FREEBOARD:	10.00 FT
AVG. SLOPE OF BERM 1:	20.00
RADIUS OF DECK:	150.00 FT
TOTALCOSTS = $ 35313911.11	

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.89	.14	.60	.09
ADAPTABILITY	.08	.00	.00	.70	.00
TRANSIT TIME	.11	.40	.04	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.42	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.50	.05	.40	.02
RELOCATABILITY	.08	.10	.01	.40	.00
ICE FORCE RESISTANCE	.16	.40	.06	.90	.06
EASE OF CONSTRUCTION	.12	1.00	.12	.80	.10
CONSTRUCTION TIME	14	.96	.13	.60	.08
			--------		--------
			SUM= .58		SUM= .38

***************SACRIFICIAL ISLAND***************

WATERDEPTH:	50.00 FT
ISLAND FREEBOARD:	12.50 FT
AVG. SLOPE OF BERM 1:	20.00
RADIUS OF DECK:	150.00 FT

TOTALCOSTS = $ 63777388.89

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.80	.13	.60	.08
ADAPTABILITY	.08	.00	.00	.70	.00
TRANSIT TIME	11	.40	.04	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.42	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.50	.05	.40	.02
RELOCATABILITY	.08	.10	.01	.40	.00
ICE FORCE RESISTANCE	.16	.40	.06	.90	.06
EASE OF CONSTRUCTION	.12	1.00	.12	.80	.10
CONSTRUCTIONTIME	.14	.95	.13	.60	.08
			--------		--------
			SUM= .57		SUM= .37

**************SACRIFICIAL ISLAND**************

WATERDEPTH:	60.00 FT
ISLAND FREEBOARD:	15.00 FT
AVG. SLOPE OF BERM 1:	20.00
RADIUS OF DECK:	150.00 FT

TOTALCOSTS = $ 104458200.00

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.83	.13	.60	.08
ADAPTABILITY	.08	.00	.00	.70	.00
TRANSIT TIME	.11	.40	.04	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.42	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.50	.05	.40	.02
RELOCATABILITY	.08	.10	.01	.40	.00
ICE FORCE RESISTANCE	.16	.40	.06	.90	.06
EASE OF CONSTRUCTION	.12	1.00	.12	.80	.10
CONSTRUCTION TIME	.14	.94	.13	.60	.08
			--------		--------
			SUM= .57		SUM= .37

***************CAISSON RETAINED ISLAND*****************

WATERDEPTH:	10.00 FT
CAISSON FREEBOARD:	2.50 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	10.00 FT
BERM RADIUS:	200.00 FT

TOTALCOSTS = $ 2278449.44

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.97	.15	.60	.09
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.57	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.60	.05	.40	.02
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.60	.10	.90	.09
EASE OF CONSTRUCTION	.12	.50	.06	.80	.05
CONSTRUCTION TIME	.14	.88	.12	.60	.07
			--------		--------
			SUM= .63		SUM= .40

***************CAISSON RETAINED ISLAND***************

WATERDEPTH:	20.00 FT
CAISSON FREEBOARD:	5.00 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	20.00 FT

BERM RADIUS: 200.00 FT
TOTALCOSTS = $ 5133058.52

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.93	.15	.60	.09
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.57	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.60	.05	.40	.02
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.60	.10	.90	.09
EASE OF CONSTRUCTION	.12	.50	.06	.80	.05
CONSTRUCTION TIME	.14	.77	.11	.60	.06
			--------		--------
			SUM= .61		SUM= .39

***************CAISSON RETAINED ISLAND****************

WATERDEPTH:	40.00 FT
CAISSON FREEBOARD:	10.00 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON	30.00 FT
BERM RADIUS:	200.00 FT

TOTALCOSTS = $ 11359786.67

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.77	.12	.60	.07
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.57	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.60	.05	.40	.02
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.60	.10	.90	.09
EASE OF CONSTRUCTION	.12	.50	.06	.80	.05
CONSTRUCTION TIME	.14	.59	.08	.60	.05
			--------		--------
			SUM= .55		SUM= .36

***************CAISSON RETAINED ISLAND****************

WATERDEPTH:	30.00 FT
CAISSON FREEBOARD:	7.50 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	30.00 FT
BERM RADIUS	200.00 FT

TOTALCOSTS = $ 9428066.67

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
	.16	.81	.13	.60	.08
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.57	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.60	.05	.40	.02
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.60	.10	.90	.09
EASE OF CONSTRUCTION	.12	.50	.06	.80	.05
CONSTRUCTION TIME	.14	.65	.09	.60	.05
			--------		--------
			SUM= .57		SUM= .37

***************CAISSON RETAINED ISLAND****************

WATERDEPTH:	50.00 FT
CAISSON FREEBOARD:	12.50 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	30.00 FT
BERM RADIUS:	200.00 FT

TOTALCOSTS = $ 15525533.33

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.61	.10	.60	.06
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.57	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.60	.05	.40	.02
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.60	.10	.90	.09
EASE OF CONSTRUCTION	.12	.50	.06	.80	.05
CONSTRUCTION TIME	.14	.52	.07	.60	.04
			--------		--------
			SUM= .52		SUM= .34

***************CAISSON RETAINED ISLAND****************

WATERDEPTH:	60.00 FT
CAISSON FREEBOARD:	15.00 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	30.00 FT
BERM RADIUS:	200.00 FT

TOTALCOSTS = $ 23042320.00

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.54	.09	.60	.05
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.57	.03	.70	.02
REPAIR COSTS (5 YRS)	.09	.60	.05	.40	.02
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.60	.10	.90	.09
EASE OF CONSTRUCTION	.12	.50	.06	.80	.05
CONSTRUCTION TIME	.14	.45	.06	.60	.04
			--------		--------
			SUM= .50		SUM= .32

**********SLOPE SIDED CAISSON RETAINED ISLAND**********

WATERDEPTH:	10.00 FT
CAISSON FREEBOARD:	2.50 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	10.00 FT
BERM RADIUS:	250.00 FT
CAISSON SLOPE 1:	1.00
HEIGHT OF CAISSON ABOVE APEX	9.00 FT
DEPTH OF CAISSON BELOW APEX:	3.50 FT

TOTALCOSTS = $ 13796493.27

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.66	.10	.60	.06
ADAPTABILITY	.08	.40	.03	.70	02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.62	.04	.70	.03
REPAIR COSTS (5 YRS)	.09	70	.06	.40	.03
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.90	.14	.90	.13
EASE OF CONSTRUCTION	.12	.27	.03	.80	.03
CONSTRUCTIONTIME	.14	.77	11	.60	.06
			--------		--------
			SUM= .59		SUM= .39

**********SLOPE SIDED CAISSON RETAINED ISLAND**********

WATERDEPTH:	20.00 FT
CAISSON FREEBOARD:	5.00 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	20.00 FT
BERM RADIUS:	250.00 FT
CAISSON SLOPE 1:	1.00
HEIGHT OF CAISSON ABOVE APEX	9.00 FT
DEPTH OF CAISSON BELOW APEX:	16.00 FT

TOTALCOSTS = $ 64123745.34

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.80	.13	.60	.08
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.62	.04	.70	.03
REPAIR COSTS (5 YRS)	.09	.70	.06	.40	.03
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.90	.14	.90	.13
EASE OF CONSTRUCTION	.12	.27	.03	.80	.03
CONSTRUCTION TIME	.14	.54	.08	.60	.05
			--------		--------
			SUM= .59		SUM= .38

**********SLOPE SIDED CAISSON RETAINED ISLAND**********

WATERDEPTH:	30.00 FT
CAISSON FREEBOARD:	7.50 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	30.00 FT
BERM RADIUS:	250.00 FT
CAISSON SLOPE 1:	1.00
HEIGHT OF CAISSON ABOVE APEX	9.00 FT
DEPTH OF CAISSON BELOW APEX:	28.50 FT

TOTALCOSTS = $ 258646846.79

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.91	.15	.60	.09
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.62	.04	.70	.03
REPAIR COSTS (5 YRS)	.09	.70	.06	.40	.03
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.90	.14	.90	.13
EASE OF CONSTRUCTION	.12	.27	.03	.80	.03
CONSTRUCTION TIME	.14	.31	.04	.60	.03
			--------		--------
			SUM= .56		SUM= .37

**********SLOPE SIDED CAISSON RETAINED ISLAND**********

WATERDEPTH:	40.00 FT
CAISSON FREEBOARD:	10.00 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	30.00 FT
BERM RADIUS:	250.00 FT
CAISSON SLOPE 1:	1.00
HEIGHT OF CAISSON ABOVE APEX	9.00 FT
DEPTH OF CAISSON BELOW APEX:	31.00 FT
TOTALCOSTS = $	305558306.95

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.89	.14	.60	.09
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.62	.04	.70	.03
REPAIR COSTS (5 YRS)	.09	.70	.06	.40	.03
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.90	.14	.90	.13
EASE OF CONSTRUCTION	.12	.27	.03	.80	.03
CONSTRUCTION TIME	.14	.24	.03	.60	.02
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			SUM= .56		SUM= .37

**********SLOPE SIDED CAISSON RETAINED ISLAND**********

WATERDEPTH:	50.00 FT
CAISSON FREEBOARD:	12.50 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	30.00 FT
BERM RADIUS:	250.00 FT
CAISSON SLOPE 1:	1.00
HEIGHT OF CAISSON ABOVE APEX	9.00 FT
DEPTH OF CAISSON BELOW APEX:	33.50 FT

TOTALCOSTS = $ 359313672.40

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.88	.14	.60	.08
ADAPTABILITY	.08	.40	.03	.70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.62	.04	.70	.03
REPAIR COSTS (5 YRS)	.09	.70	.06	.40	.03
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.90	.14	.90	.13
EASE OF CONSTRUCTION	12	.27	.03	.80	.03
CONSTRUCTION TIME	.14	.17	.02	.60	.01
			--------		--------
			SUM= .55		SUM= .36

**********SLOPE SIDED CAISSON RETAINED ISLAND**********

WATERDEPTH:	60.00 FT
CAISSON FREEBOARD:	15.00 FT
AVG. SLOPE OF BERM 1:	20.00
1/2 DECK WIDTH:	150.00 FT
DRAFT OF CAISSON:	30.00 FT
BERM RADIUS:	250.00 FT
CAISSON SLOPE 1:	1.00
HEIGHT OF CAISSON ABOVE APEX	9.00 FT
DEPTH OF CAISSON BELOW APEX:	36.00 FT

TOTALCOSTS = $ 421116380.42

	PREFERENCE (K)	UTILITY RATINGS (U)	UTILITIES [U]	PROBABILITY OF OCCURRENCE	EXPECTED UTILITIES E[U]
INITIAL COST	.16	.85	.14	.60	.08
ADAPTABILITY	.08	.40	.03	70	.02
TRANSIT TIME	.11	.30	.03	.50	.02
DEPRECIATION COSTS (5 YRS)	.06	.62	.04	.70	.03
REPAIR COSTS (5 YRS)	.09	.70	.06	.40	.03
RELOCATABILITY	.08	.50	.04	.40	.02
ICE FORCE RESISTANCE	.16	.90	.14	.90	.13
EASE OF CONSTRUCTION	.12	.27	.03	.80	.03
CONSTRUCTION TIME	.14	.11	.01	.60	.01
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			SUM= .53		SUM= .35

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Development of decision analysis specifically for Arctic offshore drilling islands.